

## Review of forest ecology studies in China

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**Abstract:** As the most important type or component in the terrestrial ecosystems, forest ecosystem makes its role obviously prominent and important on environment and human being. It possesses non-substitutable functions in the process of sustainable development. However, due to the complexity of the forest ecosystem and the relatively delay or lack of the related research technology, the science is still in the case of immature and questions. This paper summarized and reviewed briefly the development and the present case of the forest ecology, then pointed out the existing problems in the forest ecosystem researches. In the end, we discussed several fields that need to pay more attention to in future researches.

**Keywords:** Forest; Ecosystem; Forest ecology; Structure and function; Management; Health; Watershed

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### Introduction

Forest ecology, as a branch science of ecology, is an applied and basic discipline of forestry (Jiang *et al.* 1991). Spurr and Barnes (1973) considered that forest ecology was the synthetic analysis on forest ecosystem and the chief studying objective of forest ecology was forest ecosystem. As the most important type or component in the terrestrial ecosystems, forest ecosystem is very prominent and important to environment and human being. It possesses non-substitutable functions in the process of sustainable development. China, as a developing country and being short of forest resources is facing with a number of eco-environmental problems such as insufficient total amount of forest resources, severe soil erosion, desertification, shortage of water resource, and frequent natural disaster. From taking afforestation as one of the basic national policies to actualizing six forestry ecological projects including *Natural Forest Protection*, Chinese government and the whole nation have recognized the importance of accelerating the development of forestry. The achievements on forest ecology study take on important guidance to the development of forestry. In the 21st century, to meet the needs of new situations, deepening the basic theoretic studies on forest ecology and applying the scientific achievements to forest ecosystem management are still important tasks for Chinese forest ecologists.

This paper made a brief review on the development of forest ecology and its current situation in China and the problems existed in forest ecosystem research, and some

subjects on which more attention should be paid in future study were also discussed.

### Current situation and problems

From 1950s to 1980s of the 20th century, to meet the needs of forestry construction and investigation, the contents of forest ecology research had focused mainly on synthetic investigation of natural forests, and a great deal of scientific data and information about natural geography, flora, species distribution, soil types and characters, and growth process of trees had been accumulated. These researches provided the scientific basis to forestry development. During the period of "Seventh Five-year" national program (1985-1990), the research of forest ecology turned to forest site, particularly to classification and evaluation of the timberland. Some major achievements were reported in some monographs (Jiang *et al.* 1991; National Natural Science Foundation of China 1996).

Along with the implement of IBP (International Biological Program) and MAB (Man And Biosphere), forest ecology study developed quickly. It turned into a process of large scale, high expenditure, long term, and depended on complexity of ecosystem (McIntosh 1985). Therefore, long-term observation and localization study on forest ecosystems have developed greatly in the last 20 years in China. At present, Chinese Ecological Research Network (CERN) has more than 10 field research stations aimed at different forest ecosystems. After construction, observation, and study for about 20 years, these stations have already been formed into a research network in a certain scale. The stations of CERN have been the main force of forest ecology study and obtained many achievements in productivity, biomass, and eco-environmental function of forest ecosystems. "Studies on structure and function of warm temperate forest" and seven volumes of "Research of Forest Ecosystem" are the representative monographs.

Along with the increase of environmental problems,

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studies related to environment have been the emphasis of forest ecology. For example, the relationship between forest ecosystem and air pollution, especially acid rain, has been greatly studied and some valuable achievements have been obtained. Furthermore, the actual hot spots of forest ecology are as follows: (1) response of forest ecosystems to global change; (2) relationship between carbon cycle and forest ecosystems; (3) influences of disturbance (especially human activities) on forest ecosystems; (4) biodiversity conservation and forest ecosystem; (5) services of forest ecosystem and its evaluation; and (6) forest ecosystem health.

Structure and function of forest ecosystems are the important and basic research contents of forest ecology. However, due to the complexity of the forest ecosystem and the relatively delay or lack of the related research technology, the science of forest ecology is still in the stage of immature or developing. The actual problems of forest ecology study in China are as follows: (1) most of studies focusing on community and few studies on region; (2) insufficient combination and translation among studies under different scales; (3) more descriptive studies and less studies on process and mechanism; (4) insufficient cooperative studies under scale of system; (5) insufficient standardization in long-term observation; (6) insufficient combination between new idea and actual case study; and (7) insufficient original innovative study.

### **Developing trends of forest ecology**

In the recent 20 years, forest ecology study has advanced in the following aspects: (1) the change of different forest ecosystems disturbed by human activities; (2) growth, development, succession, and population dynamics of different natural forests and artificial forests; (3) material cycle in artificial forest; (4) ecological services of forest ecosystems and its evaluation; (5) function of forest in global change; (6) harm of acid sedimentation on forest and its prevention; (7) protection and conservation of forest ecosystems; and (8) relationship between forest and water.

According to the above mentioned study contents, the main trends of forest ecology study can be summarized as follows: (1) focusing on complexity of forest ecosystem under different biological layers and tempo-spatial scales; (2) emphasizing process and dynamics; (3) emphasizing temporal and spatial scale; (4) attaching importance to long term observation; (5) emphasizing effects of human; and (6) paying more attention on global change and biodiversity.

In America, forest ecology study tends to focus on the biodiversity and responds of forest ecosystem to global change, and the research methods mainly emphasize application of experimental ecology (Chen *et al.* 1993, 1994), with characteristics of localization, long-term, comprehension, and polarization in studying level (Chen *et al.* 1994). All these reflect a prime developing current and main

characteristics of forest ecology. Undoubtedly, following the overseas studies up to date is an important approach to improve forest ecology study in China, however, the following must be combined with the actual problems and aims at forestry practice in China.

### **Thoughts on important aspects of forest ecology**

#### **Structure and function of forest ecosystem**

Forest is one kind of biological community that is mainly composed of trees and other plants. As the most important type or component in the terrestrial ecosystems, forest ecosystem has obvious effects on environment and human being, and the effects are related closely to structure and function of forest ecosystem. Although some common viewpoints are formed on functions or ecological benefits of forest ecosystem, the idiographic structure and function of forest ecosystem cannot be discussed in details, and the structure and function (especially function) are not studied expressly. Certainly, some reasons, such as complexity and diversity of forest ecosystem, and relatively undeveloped research method and measure, would limit the improvement of study on structure and function of forest ecosystem. However, another important reason that would limit the improvement of the studies is the ignorance of the long-term study. Study projects of Hubbard Brook (Borman *et al.* 1981) and Andrews are famous for the long-term and synthetic study, and have got a lot of achievements. On the contrary, CERN has been constructed for 20 years, but there is no parallel station or study project.

Furthermore, inadequate recognition on scale is another chief problem in Chinese forest ecology study. There are often detailed studies on quadrats or a small block of forest, but the results can't be applied in larger scale. Therefore, these results may be correct, but it is difficult to extrapolate and apply in a large scale.

Although forestry ecology has many important study aspects, the studies on structure and function of forest ecosystem are still basic and the more important. To strengthen and develop studies on structure and function of forest ecosystem, the following attentions should be paid: (1) stable research groups; (2) continuous funding support and research; (3) emphasizing temporal and spatial scale; and (4) application of high and new tech.

#### **Forest ecosystem management**

Early attempts to conserve and sustain wood supplies had been largely unsuccessful. Regulations and ordinances based on short-term economic and political rather than biological principles are not an adequate basis on which to develop successful sustained-yield forest management (Kimmens 1987). A viewpoint that forest has ecological, economic, and social benefits has been widely accepted, and forest ecosystem management has been a modern and important term. Forest ecosystem management can be defined as "maintaining forest's capabilities of

productivity and regeneration, and biodiversities of forest ecosystem without unacceptable damaging in a long term". Namely, sustainable forest ecosystem management contains three important factors: productivity, renewability, and biodiversity. Forest ecosystem management aims at forest ecosystem with little attention on landscape. So, landscape design should be the fourth factor of sustainable forest ecosystem management, and the design should be carried out under larger scale.

An important viewpoint should be put forward as 'between economic benefit and ecological benefit, which is more important to forest ecosystem management'. Much of traditional economics is concerned with expanding economies, with growth, and with maximizing short-term returns on investment (Kimmims 1987). In this paper, economics and ecology are dancing to different tunes (Kimmims 1987). However, economics in its broadest sense is homologous to ecology; it is a branch of human ecology, which studies the interactions and exchange of energy and materials among individuals in socioeconomic systems.

Another important viewpoint that is worth to be devoted is to manage forest ecosystem as one kind of natural resource. As a kind of resource, renewability or nonrenewability is the key content of forest resource. Forests are certainly not inherently renewable resources. The difference between renewable and nonrenewable resources lies more in the rate or time of their renewal than in the physical, chemic, or biological character of the resource per se (Kimmims 1987). The fundamental tenet of sustainable management is that the resource is renewable, but forest resource can be renewable or nonrenewable, and the distinction is not absolute. In many areas, it is largely dependent upon the type of forest management employed (Kimmims 1987). Therefore, forest ecosystem management must accord with ecological principles; otherwise the renewability of forest resource cannot be maintained or enhanced. Quality and intensity of management is the key, furthermore, classification management aimed at different forest resources is also an important content.

#### **Forested watershed ecology and riparian management**

Attention on management of streams, lakes, and wetlands in forest ecosystems or watersheds represents one of the most revolutionary changes in forestry in the latter half of the 20th century. There is a widespread agreement that historical forest practice has negatively altered the structure of the aquatic ecosystems and decreased their productivity (Gregory 1997). Along with the continuous development of researches on stream ecosystems (Chen 1996; Minshall *et al.* 1985) and watershed ecology (Deng *et al.* 1998), the intercross and combination of terrestrial ecosystem and aquatic ecosystem researches are a new current in ecosystem studies, and riparian zone becomes an important content of forested watershed ecology.

Riparian zone is the interface between aquatic ecosystem and terrestrial ecosystem. It has obvious gradients of

environmental factors, ecological process, and plant communities (Gregory *et al.* 1991). Riparian zone is the key ecosystem controlling the adjacent aquatic ecosystem and terrestrial ecosystem. Riparian plant community, which is the important component of riparian natural landscape, has high productivity and biomass. Riparian zone, which is the suitable habitat for some animals, offers the corridor for movement of some animals and plants, and has an important function in buffering soil erosion and non-point resource pollution (Deng *et al.* 2001). Thus, it is obviously important that riparian zone management is a major part of entire ecosystem management. Riparian zone management bases on ecosystem management, and its core content is the management of riparian vegetation, especially riparian forest. The object is to protect freshwater ecosystem and all kinds of resources relative to riparian zone, and to provide suitable habitat. Some studies showed that advisable riparian management could exert the function of riparian, and width of riparian zone is a key problem. Generally, exterminating width of riparian zone depends upon size and width of river, height of live trees in the riparian zone, and ecological process in the riparian zone. Besides widths of riparian management zones, current riparian management focuses on several issues (Gregory 1997): (1) retention of live trees and snags within the riparian zone, (2) the extent of shade cover, (3) floodplain protection, (4) yarding corridors, (5) culvert dimensions, (6) road crossing, (7) felling techniques, and (8) erosion protection.

The developing trend of riparian management is dynamic owing to ecological, economic, and social factors, but the current trends can be concluded as: (1) more intercross and combination of terrestrial ecosystem and aquatic ecosystem researches and management, (2) emphasis on ecological function and natural forest pattern, (3) adoption of a landscape perspective of river networks, (4) application of ecological modeling, (5) correct cognition of relationship among ecosystem management, engineering measurement, and human disturbance.

#### **Forest ecosystem health**

Forest ecosystem health (forest health) is a relatively new term in forestry (Norton 1992). It has been increasingly used in several articles of forestry and natural resource management in recent ten years, even the subject of the policy report and plan, especially in USA. Early use of this term is related to the forest decline phenomena, such as defoliation before mature, canopy sparsity, decolor, leaf curling, large area forest death, and threaten of plant diseases and insect pests (Waring 1980; Smith 1985, 1990; O'Laughlin 1994). Undoubtedly, most contemporary views of forest ecosystem health came from the writings of Aldo Leopold (Leopold 1949; Zeng *et al.* 1999). Now, notion understanding for forest ecosystem health is based on two approaches: objective-oriented approach focuses on forest management objectives and ecosystem-oriented approach focuses on forest ecosystem function.

There are several questions in defining forest health or considering whether the forest is in health or not: (1) Management to achieve objectives requires a clear and explicit statement of those objectives, so the managers know whether they are on target to meet the objectives; (2) Objectives must reflect limitation posed by ecosystem characteristics and properties; and (3) Human inevitable effect and value judgment on forest.

Although monitoring and valuation for ecosystem health, and subsequent management countermeasure become the hotspot of forest ecosystem research, the in-depth studies on forest ecosystem health have been restricted by insufficient knowledge about forest structure and function. As the base of resource management and sustainable development, forest ecosystem health means the well-balanced maintain of ecosystem structure, good exertion of its' function and sustainable ecological services. Some current studies on ecosystem health only aim at the term "health" and break away the ecosystem structure and function. This is a questionable shortcoming. Monitoring and valuation for forest ecosystem health should start with forest ecosystem structure and function research, proceed from single tree to landscape scale, build up observation index on long-term scale, and study the succession process and dynamic of forest ecosystem.

Because forest ecosystem health is a new research field, at present, it's difficult for us to confirm the ecological indicators for a certain forest ecosystem. A simple way is to monitor all ecological indexes, and then filter them. This is what we are doing for the evaluation on health of broad-leaved and Korean pine forest in Changbai Mountain in China. We emphasize particularly on the lichen, insect, soil and soil animal and microbe, and so on. Based on integration of these results, we should be able to answer the question that what is the healthy broad-leaved Korean pine forest.

## Conclusion

Forest is a natural ecosystem with huge function and takes unthinkable and profound effects on human. Going deep into understanding the structure, function, and development of forest ecosystem is the basis of sustainable strategy. As a subject of research on the forest ecosystem, forest ecology has great commonweal and wide applications. At the same time, it is also a comprehensive science, which needs many subjects to support. Forest ecology communicates with various natural sciences reciprocally, and is closely linked with the economics and social sciences. Due to the long life cycle and complexity of forest ecosystem, it is evident, comparing with other sciences, that forest ecology has the relative lag and tardiness in its development. Thus, it is still an important task to adapt the new situations and demands, to deepen the basic theoretic studies on forest ecology, and to apply the achievements in forest ecosystem management.

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